ORIGINAL RESEARCH

To Compare Study Between Intramedullary Nailing and Plating for Extra Articular Distal Tibia Fracture

Ashok Patel[1], Manoj Sharma[2], Ishwar Meena[3], Ashwani Bilandi[4]

[1]Senior Resident, [2,3,4]Assistant Professor,Department of Orthopaedics,Mahatma Gandhi Medical College & Hospital, Jaipur, Rajasthan, India

Corresponding Author
Dr. Ashwani Bilandi
Assistant Professor,Department of Orthopaedics,Mahatma Gandhi Medical College & Hospital, Jaipur, Rajasthan, India
Email:ashwani.bilandi@gmail.com

Received: 02 March, 2024 Accepted: 08 April, 2024

ABSTRACT
The aim of the study compares intramedullary nailing and plating for extra articular distal tibia fracture among 50 patients admitted in Mahatma Gandhi Medical College & Hospital, Jaipur during the study period of 12 months.Patients fulfilling the inclusion criteria were included in the study. All patients were enrolled in this study and randomized and allocated into two groups.Group A (n=25) operated with distal tibia locking plate and patients in Group B (n=25) operated with intramedullary interlocking nail.All cases of intramedullary nailing were done by closed reduction by patellar tendon splitting approach. Plating was done by Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique.In results, the mean age in nailing group was 46.0 ± 15.18 years whereas in plating group it was 43.0 ± 12.72 years (P>0.05). The majority of patients were males, in their fourth to fifth decade of life and road traffic accidents were the most prevalent cause of injury.The excellent and good outcomes of 25 patients operated with distal tibia locking plating, followed by 21 patients had an excellent and good outcomes operated with intramedullary nailing.In conclusion, both closed intramedullary nailing and a locked compression plate are both effective in treating fractures of distal tibia. Nailing resulted in better range of motion at ankle joint and earlier fracture healing in comparison to plating. Weight bearing can be started early with interlocking nailing. This study suggests IMN might be slightly superior in reducing postoperative complications when compared to plating, but there was no difference in functional outcomes.
Keywords:Intramedullary Nailing, Distal Tibia Locking Plate, Fractures.

INTRODUCTION

With the advent of industrialization, there has been a rising trend of the occurrence of motor vehicle accidents. This led to a logarithmic growth in the incidence of fracture of various bones of the body. On reviewing the data on incidence fractures in body parts, tibial fractures come at the top because it forms the distal part of the body and is subcutaneous in nature.[1] Among the tibial fractures, a majority of fractures involves the distal tibia; these fractures are usually comminuted in nature and are highly unstable. The distal tibial fractures have been daunting to manage because they often result in unsatisfactory outcomes on surgical treatment and conservative approach leads to mal-union/ nonunion.[2] Distal tibial fractures has certain peculiarities not only regarding its anatomy but also associated injury factors which make it a fracture vulnerable to end up in complications. They are distal part of locomotive system, bone is subcutaneous in whole extent with minimal soft tissue cover, fracture often associated with breach of soft tissue, often comminuted, blood supply in distal third is often scanty and salvage procedure (flap coverage, vascular repairs often) have high failure rates leading to limb salvage a difficult problem.[3]

Distal tibial fractures caused by high energy trauma are associated with fibular fractures in 70% of cases. Fixation of these fibular fractures is required or as result in precise alignment and shortening of tibia. due to the presence of interosseous membrane between two leg bones there is sharing of load by fibula when there is disruption of interosseous membrane tibia remain the only bone which bear the weight .so the fibular fracture with syndesmotic disruption should be treated operatively as it might had to adverse result.

Fractures of distal third tibia have been known since the times of Hippocrates and have always been difficult to treat. These fractures are eponymously known as potts fracture on the name of Sir Percivall Potts (1768).[4] AO classification is the most simple and effective tool to classify these fractures based on mechanism of injury and severity. They also are efficient in assessing prognosis and help in clinical and management judgment. Soft tissue injuries associated with these fractures have been classified by Gustilo which is now accepted worldwide (1976). Conservative treatment, external fixation, interlocking nail and open reduction with plate fixation are various treatment modalities that are employed for distal tibia fracture.[5]

In our study we divided patients in two group that is consists of the extra articular distal tibia fracture which treated by ORIF with plating and consists of those fractures in extra articular distal tibia fracture with treated by interlocking nail. In this study where fibula was fractured both bones are fixed with lateral plate with single anterolateral incision. While where fibula is intact medial plate are used. There are cases which are less comminuted intramedullary nailing is done.

OBJECTIVES

1. To evaluate the outcome of intramedullary interlocking nail with extra-articular distal tibia fractures and complications and treatment.
2. To evaluate the outcome of ORIF with medial/lateral plating with extra-articular distal tibia fractures and complications and treatment.
3. Compare both technique.

METHODOLOGY

The form of treatment (Intra medullary interlocking nail or distal tibia locking late) was decided randomly. Out of 50 patients, 25 patients were operated on with distal tibia locking plate and 25 patients were operated on with intramedullary interlocking nail.

All cases of intramedullary nailing were done by closed reduction by patellar tendon splitting approach. Plating was done by Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique, which was converted into open reduction and internal fixation in case of difficulty to reduce fracture by closed technique. All 25 cases (15 lateral and 10 medial) of plating were done by medial/lateral approach. In all cases fractured fibula within 7 cm of ankle joint were fixed with open reduction internal fixation with 3.5 mm 1/3 tubular plate and screws. Where the fibula was fractured both bones are fixed with lateral plate with single anterolateral incision. While where fibula is intact medial plates are used. There are cases which are less comminuted intramedullary nailing is done.

With this procedure we achieve anatomical reduction. It was done as a planned and elective procedure. Before patients were taken up for surgery, they were put on limb elevation in above knee plaster splint and anti-inflammatory drugs and antibiotic for 7 days to reduce swelling. Third generation cephalosporin was administered intravenously as preoperative antibiotic prophylaxis one hour before starting surgery. Post operatively limbs were immobilized in plaster splint in all the cases for two weeks till soft tissue edema settled.

Patients were put on intravenous antibiotics and analgesics and limbs were kept elevated. Sterile dressings of operative wound were done on day 3rd and sutures were removed on 11-15th day (decided according to the wound inspection). Slab was discontinued after two weeks in all the patients and all patients were encouraged to perform Ankle and knee non weight bearing mobilization. Those patients who followed post-operative instructions were advised strict non weight bearing walking. Patients were advised to keep the limb at elevation at night times and perform active movements of ankle joints. Patients were assessed for fracture union radiologically. At six weeks once the fracture showed signs of radiological union, partial weight bearing was advised. Patients were assessed for fracture union radiologically. At ten weeks after assessment of x-ray allowed full weight bearing was advised.

Follow up: Weight bearing was restricted till fracture site showed callus formation. At 6 weeks x-ray of the Tibia was taken in AP and lateral views, and there after every month X- rays were taken and looked for signs of fracture union and then advised partial weight bearing once the fracture showed signs of union. It was then gradually increased to full weight bearing. Regular follow up was done at monthly intervals till 24 weeks after operation till the fracture united. Follow up X-rays were taken to assess fracture union, the condition of implant.

Radiological Evaluation: Radiographic union was defined as 'radiographic' evidence of bridging cortical bone on at least three cortices. Malalignment of the tibial shaft was defined as >5° of varus/valgus angulation and >10° of anterior / posterior angulations. The angle between distal part and the proximal part of the tibia was determined by measuring the angle between the line through the center of tibia plateau down the middle of proximal shaft, and the line from the center of ankle up the middle of the distal shaft in an antero-posterior radiograph. Measures of angulations were obtained from radiographs taken immediately after the surgery and at 6 months follow up. Angles were measured using RadiAnt DICOM Viewer software package.

Statistical Analysis

All the demographic details, base line data and postoperative data were recorded in the case report form over the course of the study. Olerud and Molander Functional scoring system[6] was used to evaluate the patients at the end of 6th month. Score and fracture union in both the groups were compared using unpaired t-test. Finally, correlation between

results of the score and clinical data were evaluated using chi-square test. Probability was considered to be significant if less than 0.05. The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 22.0 statistical Analysis Software.

RESULTS

The mean age in nailing group was 46.0 ± 15.18 years whereas in plating group it was 43.0 ± 12.72 years (P>0.05). Majority of the patients (52%) included in the study were in the age group 36-55 years (P>0.05). 39(78%) were male and 11(22%) were female. Actively working groups are more prone for RTA and female which have sedentary lifestyle are common for fractures (P>0.05). 32(64%) had distal tibia fracture on right side and 18 (36%) had distal tibia fracture on left side, so right side are dominating and more involved compared to left side. 30(60%) had distal tibia fracture due to Road traffic accident and 20 (40%) had distal tibia fracture due to Domestic accident. 19(38%) had AO/OTA 43A1 type fracture, 20(40%) had 43A2 type fracture and 11(22%) had 43A3 type fracture of distal tibia (P>0.05).

Maximum number of cases (68%) with 43 A1 fracture type were operated with intramedullary nailing. Similarly, maximum number of cases (73%) with 43 A3 fracture type were operated with Plating (P<0.05). 45(90%) had Primary union and 5(10%) had delayed union. There was no patient with non-union (P>0.05). All the patients (100%) in nailing group had primary bone union. All the patients with infection were from the plating group. None of the patients from the nailing group had infection. 2 (8%) patients from the nailing group had valgus malalignment. There was no patient in plating group with malalignment (P>0.05).

The mean range of dorsiflexion in nailing group at the end of 6 months was 12.6 degrees as compared to 9.6 degrees in plating group, with mean difference of 3 degrees (P>0.05). Mean range of dorsiflexion of all types of fractures in nailing group was 12.6 degrees and in plating group it was 9.6 degrees (P>0.05). The mean range of plantar flexion in nailing group at the end of 6 months was 32.4 degrees as compared to 25.0 degrees in plating group (P<0.01). Mean range of plantar flexion of all types of fractures in nailing group was 23.4 degrees and in plating group it was 25.0 degrees (P<0.05). Average time after which patient was allowed full weight bear on the operated limb was 14.2 ± 1.12 weeks and in plating group was 17.3 ± 0.94 weeks (P<0.01). Average time for which patient was allowed to full weight bear of all types of fractures in nailing group was 14.2 weeks and in plating group it was 17.3 weeks (P<0.05). Average time taken for radiological union according to fracture types in nailing group was 19.1 ± 1.14 weeks and in plating group it was 23.8 ± 1.16 weeks (P<0.01). The mean Olerud and Molander Functional scores at the end of 6 months for nailing group was 83.4 and for plating group was 74.4. The mean score in nailing group was found to be better as compared to plating group.

Out of the 50 patients treated, 58% had good results, 22% had excellent results and 20% had fair results. When Chi-square test was applied to compare the difference in functional scores of both the groups, there was no significant difference among both groups statistically (P>0.05) (Table 1). Comparison of mean functional scores according to fracture type after 6 months in nailing group was 87.3 and in plating group it was 77.5 (P<0.05).

Table 1: Results according to Olerud and Molander Functional scoring system

Operative Procedure		Nailing	Plating	Total	Chi-square	P value
OLERUD-MOLANDER SCORE	Excellent	7	4	11	2.453	0.293
		28%	16%	22%	df =2	
	Good	15	14	29		
		60%	56%	58%		
	Fair	3	7	10		
		12%	28%	20%		
	Poor	0	0	0		
		0%	0%	0%		
	Total	25	25	50		

Interpretation: Out 50 patients, 10 had open wounds. When the mode of definitive management was by plaiting, the patients typically attained 9 degrees of ankle dorsiflexion and 25 degrees of plantar flexion. Similarly, patients who underwent intra medullary nailing attained a 12.9 degrees of ankle dorsiflexion and 32.4 degree of plantar flexion. The quantity of intraoperative blood loss that was compared between the two groups revealed that the average blood loss among patients who underwent plating was 140ml, with a maximum blood loss of 170 ML on three instances and a maximum blood loss of around 220 ml in two cases. The intramedullary interlocking nailing patients experienced mean blood loss of about 90 mL, with a maximum of 120 ml in two patients. In the 25 cases with nailing, the average time was 45 -70 minutes; the longest case took 80 minutes, while the shortest case was done in 38 minutes. The median operative time for 25 patients who underwent plating was 60 to 80 minutes, Intramedullary nailing required 19.1 weeks for radio-logical union, compared to 23.8 weeks for medial /lateral plating patients. With respect to complications, a total of 1 patient treating with plate experienced superficial wound infection,

amongst the patients that underwent plating. By 18 weeks, all of the patients had functionally stopped using their walking aids. While comparing the outcomes, 18 patients out of 25 had excellent and good outcomes, while 7 patients had a fair outcome for those operated for plating. Those who underwent intramedullary nailing, 21 patients out of 25 had an excellent and good outcome, while 7 patients had a fair outcome.

DISCUSSION

Distal tibia fractures are the most common significant lower extremity injuries. The treatment of distal tibia fractures with accurate open reduction or closed reduction techniques using both treatment modalities by stable internal fixation using AO method and principles was found to give a high percentage of good results. In this study the outcomes of distal tibia fractures treated with distal tibia locking plate and interlocking intramedullary nail were evaluated and compared. The results of present study are compared to with those of previous similar studies.

This study indicates that males are exposed to more risk factors due to high demanding physical work, and traveling. There was male predominance in this series, which was also observed in similar study conducted by Mohammed A et.al.[7] in which mean age of cases was 42 years with male to female ratio 4:1 and most common mode of trauma was road traffic accident.

Road traffic accidents were the most common cause of injury in this study. More than half of the patients (60%) had fracture of lower end tibia due to road traffic accidents in our series. This result suggests that road traffic accidents are a major cause of trauma involving lower end tibia than other mode of injuries. We included only extra-articular distal tibia fractures i.e. type 43 A1, A2, A3 according to AO classification of lower end tibia fractures. In this series, the majority of patients (40%) had 43 A2 type of distal tibia fracture. 38% of patients had 43 A1 type fractures. The remaining 22% of patients had 43 A3 type fracture of distal tibia.

Maximum number of cases (68%) with 43 A1 fracture type were operated with intramedullary nailing. Similarly, maximum number of cases (73%) with 43 A3 fracture type were operated with Plating. So, as the complexity of fracture pattern increased there was more difficulty in stabilizing the fracture with intramedullary nail. Simple fractures were easy to stabilize with intramedullary nail. When comparison was done with each type of fracture, there was significant association between type of fracture and treatment modality (P value 0.01). In our study, the operating time in the intramedullary nailing group ranged from 45 to 70 min (mean 57.14 ± 8.30 min), while in case of lock plate it ranged from 60 to 80 min (mean 66.67 ± 5.55 min). This was comparable to studies done by Guo et al., Li et al., Pawar et al., Yao et al.[8,9,10]

Tibial fractures are often associated with fibular fractures which might impact the treatment modality and ultimately the final reduction and union. Fixation of fibula was done with anterolateral incision in 15/25 cases (60%) in our study. The mean time for starting partial weight bearing in IMLN group was 4.95 ± 1.07 weeks as compared to 6.90 ± 1.33 weeks in MIPO group which was statistically highly significant. In our study, we allowed partial weight bearing only after signs of the union in form of bridging callus on at least three cortices out of four cortices on radiograph and clinically as the absence of tenderness and movement at the fracture site 7 which was usually by 6–8 weeks. The majority of the cases, having fulfilled above criteria around 6–8 weeks and were allowed partial weight-bearing on the affected limb.

Average time after which patient was allowed full weight bear on the operated limb was 14.2 weeks in nailing group and 17.3 weeks in plating group. So, patients of nailing group started full weight bearing earlier compared to plating group. This result was found to be highly significant statistically with a P value of 0.001. When comparison was done with each type of fracture, there was significant difference in mean values of average time to full-weight bear according to fracture type in both the groups (P value 0.002). Jayesh V Vaza et.al.[11] in their prospective study of 40 patients had a similar result, where time to full weight bearing was significantly earlier in IM nailing group (p=0.05).

Better range of ankle motion was noticed in nailing group as compared with plating group. Average dorsiflexion at the final follow-up in nailing group was 12.6 degrees and 9.6 degrees in plating group, which was statistically significant (P value 0.025). There was no significant difference in mean values of range of dorsiflexion according to fracture type in both the groups (P value 0.533). Average plantarflexion at the final follow-up in nailing group was 32.4 degrees and 25.0 degrees in plating group, which was statistically significant (P value 0.001). There was significant difference in mean values of range of dorsiflexion according to fracture type in both the groups (P value 0.034). In this study, Significant better mean range of dorsiflexion and plantar flexion were obtained in nailing group compared to plating group. This could be attributed to stripping of the muscles and tendons during open reduction while plating and prolong duration of protected weight bearing after plating. In a similar study by Im GI et.al.[12] Average dorsiflexion at final follow-up in nailing group was 14 degrees and 7 degrees in plating group, which was statistically significant (P value 0.001). In a study by Mudgal Ashwani et.al.[13] Ankle stiffness was the main complication.

2 patients (4%) presented with valgus malalignment of >5 degrees in nailing group. None patient in plating group had mal-alignment. The difference was not statistically significant (P value >0.05). In series by Sean et.al.[14] fixation of fibula by Plate and screws was

done in 52 % of patients, and they observed malalignment in only 2.7% of cases. In a similar study by Krishan A et.al.[15] they reviewed 35 patients; they observed two patients had malalignment (angulation of >5 degrees in any plane). Jayesh V Vaza et. al.[6] observed Mean Angulation in IM nailing group was 3.4 degree and 1.0 degree in plating (p=0.04). Acceptable alignment was good in their series similar to our study.

Average time taken for radiological union in nailing group was 19.1 weeks and in plating group it was 23.8 weeks with a highly significant statistical difference (P value 0.001). So, union occurred earlier in nailing group in this study. When comparison was done with each type of fracture, there was significant difference in mean values of average time to full-weight bear according to fracture type in both the groups (P value 0.003). In a similar study of 40 patients by Jayesh V Vaza etal.[6] average time before union was 23.45 weeks in IM nailing group and 26 weeks in plating group (p=0.09). In another study of 64 patients by Im GI et. al.[12] mean time of radiologic union was 18 weeks in intramedullary nailing and 20 weeks in plating group (p = 0.89). Kasper W et. al.[16] in a retrospective analysis of 24 patients observed mean time to radiographic union of 21 weeks for the ORIF group versus 19 weeks for the IM nailing group (p=0.44). Mudgal Ashwani et.al[8] in their study obtained time for union was of 21.70 weeks by MIPO technique. All the results were comparable to this study.

All the patients in nailing group had primary bone union. Out of 50 patients, 5 patients (10%) had delayed union. All the patients with delayed union belonged to plating group. 1 patient (10%) with 43 A2 fracture type and 4 patients (50%) with 43 A3 fracture type in plating group had delayed union. So the incidence of delayed union was more in 43 A3 fracture type. We did not have any cases of non-union. When comparison was done with each type of fracture, there was significant association between type of fracture and type of union (p value 0.003). In a similar study, Kasper W et.al.[11] Observed 2 cases (16.7%) of delayed union with ORIF with plating group. Sean et al.[9,17]in his series, found 19.44% of delayed union, 11% united after dynamisation and 8% required open bone grafting. None of the patients in nailing group required dynamisation in this study. Fixation was static in all cases in this study.

In this study out of 50 cases, the only post-operative complication we encountered was infection. We found deep infection at the operative site in 1 patient (2%). All the patients who were presented with post-operative infection belonged to plating group. The result was highly significant statistically (P value 0.004). None of the patients in nailing group had operative site infection. Krzysztof Piatkowski et.al.[18] in their study of 45 patients observed late infection reaching the metal implant that required admission and treatment at the septic ward was noted in five patients (11.1%).

In this study, 16 (64%) out of 25 cases in plating group were operated with Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique. Rest 9 (36%) cases wherein there was difficulty in achieving acceptable reduction intraoperative by closed means, open reduction and internal fixation was done. Failure of nail or interlocking screws is reported complication in intramedullary nailing of distal tibial fractures. We did not observe any cases of nail failure in this study. Robinson et.al[19]had 1 nail failure in his study.

The mean Olerud and Molander Functional scores[6] in this series, at the endof 6 months for nailing group was 83.4 and for plating group was 74.4. The meanscore in nailing group was found to be better as compared to plating group. Thecurrent study showed that excellent to good results were achieved in 88% of patientsin nailing group (treated with intramedullary interlocking nail) and 72% of patients inplating group (treated with distal tibia locking plate) according to Olerud andMolander scoring system. Although, the difference was statistically not significant (Pvalue 0.293). When comparison was done with each type of fracture, there wassignificant difference in mean values of functional scores according to fracture typein both the groups (P value 0.003). Similar results were obtained by Im GI et.al.[12]where the Olerud and Molander functional ankle score was 88.5% of normal side inintramedullary nailing and 88.2% in plating group (p=0.71) which was notstatistically significant.

Overall results were comparable to our study, and the majority of patients had goodresults.

CONCLUSION

Both closed intramedullary nailing and a locked compression plate are both effective in treating fractures of distal tibia. Nailing resulted in better range of motion at ankle joint and earlier fracture healing in comparison to plating. Weight bearing can be started early with interlocking nailing. Surgical site and wound complication were slightly more with open reduction and plating and screw fixation of distal tibia fracture required long periods of non-weight bearing. This study suggests IMN might be slightly superior in reducing postoperative complications when compared to plating, but there was no difference in functional outcomes. Small sample size and no long term follow up remain the limitations of this study.

REFERENCES

1. Buechsenschuetz KE, Mehlman CT, Shaw KJ, Crawford AH, Immerman EB. Femoral shaft fractures in children: traction and casting versus elastic stable intramedullary nailing. J Trauma. 2002;53(5):914–21.
2. Tile M. Fractures of the tibia. Schatzker J, Tile M, eds. The Rationale of Operative Fracture Care. 2nd ed. New York, NY: Springer-Verlag; 2000
3. Koval KJ, Zuckerman JD, eds. Handbook of Fractures. 2nd ed. Baltimore, Md: Lippincott, Williams & Wilkins; 2002.

4. Court-Brown CM. Epidemiology of fractures of the tibia and fibula. Court-Brown CM, Pennig D, eds. Tibia and Fibula. Oxford, United Kingdom: Butterworth Heinemann; 1997.
5. Girish Sahni, H.S. Mann, Ranbir Singh, Tajinder Bhalla, Comparative Study of Interlock Nailing Versus Dynamic Compression Plating in Fractures of Tibia – A Study of Sixty Cases January 2015 Indian Journal of Orthopaedics Surgery 1(4):197
6. Olerud C, Molander H (1984) A scoring scale for evaluation after ankle fractures. Arch Orthop Trauma Surg 103: 190-194.
7. Mohammed A, Saravanan R, Zammit J, King R. Intramedullary tibial nailing in distal third tibial fractures: distal locking screws and fracture non-union. Int Orthop. 2008; 32(4):547-549.
8. Pawar, E. D., Agrawal, S. R., Patil, A. W., Choudhary, S. & Asadi, G. A comparative study of intramedullary interlocking nail and locking plate fixation in the management of extra articular distal tibial fractures. J. Evol. Med. Dent. Sci.3, 6812–6826 (2014).\
9. Guo, J. J., Tang, N., Yang, H. L. & Tang, T. S. A prospective, randomised trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. J. Bone Joint Surg. Br. 92, 984–8 (2010).
10. Li, Y. et al. Comparison of low, multidirectional locked nailing and plating in the treatment of distal tibial metadiaphyseal fractures. Int. Orthop. 36, 1457–1462 (2012).
11. Vaza JV, Chauhan BR, Chauhan GR, Chauhan PR. Comparative study of plating versus nailing in distal tibia metaphyseal fractures. National Journal of Medical Research. 2014 Dec 31;4(04):340-4.
12. Im GI, Tae SK. Distal metaphyseal fractures of tibia: a prospective randomized trial of closed reduction and intramedullary nail versus open reduction and plate and screws fixation J Trauma. 2005 Nov;59(5):1219-23
13. Mudgal Ashwani, Daolagupu Arup K., Agarwala Vikash and Sinha Abhinit K Management of fractures of the extra articular distal tibia by minimally invasive plate Osteosynthesis—A prospective series of 21 patients. Int J Med Res Health Sci.276-282.
14. Sean E. Nork, Alexandra K. Schwartz, Julie Agel, Sarah K. Holt, Jason L. Schrick, Robert A. Winquist. Intramedullary Nailing of Distal Metaphyseal Tibial Fractures: J Bone Joint Surg Am, 2005 Jun 01;87(6):1213-1221.
15. Krishan A, Peshin C, Singh D. Intramedullary nailing and plate osteosynthesis for fractures of the distal metaphyseal tibia and fibula JOrthop Surg (Hong Kong). 2009 Dec;17(3):317-20.
16. Kasper W. Janssen, Jan Biert, and Albert van Kampen Treatment of distal tibial fractures: plate versus nail A retrospective outcome analysis of matched pairs of patients Int Orthop. 2007 Oct; 31(5): 709–714.
17. Krettek C, Miclau T, Schandelmaier P, Stephan C, Mohlmann U, Tscherne H. The mechanical effect of blocking screws in stabilizing tibia fractures with short proximal or distal fragments after insertion of small-diameter intramedullary nails. J Orthop Trauma. 1999;13:550-3.
18. Piatkowski K, Piekarczyk P, Kwiatkowski K et al. Comparison of different locking plate fixation methods in distal tibia fractures International Orthopaedics (SICOT). 2015; 39:2245. doi:10.1007/s00264-015-2906-4
19. Robinson CM, McLauchlan GJ, Mc Lean IP, Court-Brown CM (1995) Distal metaphyseal fractures of tibia with minimal involvement of ankle: classification and treatment by locked intramedullary nailing. J Bone Joint Surg Br 77: 781-787.